The ITU Radiocommunication Assembly,

considering

a) that for ground-wave field strength prediction, it is essential to know the electrical characteristics of the ground along the path. In cases involving coordination between administrations, it is therefore often necessary to know the ground characteristics existing outside national boundaries;

b) that the most important electrical characteristic of the earth for frequencies below 3 MHz is the conductivity;

c) that there is a need for suitable conductivity charts when planning all types of radiocommunication, including navigational services, in the VLF, LF and MF bands;

d) that conductivity maps are not yet available from all administrations;

e) that long range navigation systems use the phase information of the ground wave, paths often cross several countries, and that it is important to have reliable conductivity information along the whole path;

f) that it is of importance to keep accurate information on secondary phase conditions, which again depend on conductivity,

recommends

1 that the information contained in Annex 1, which is a World Atlas of Ground Conductivities, be used to obtain the best estimate of conductivity for planning purposes;

2 that in presenting new or revised conductivity maps for updating the Atlas, standard values be used as indicated in Table 1.

ANNEX 1

World Atlas of Ground Conductivities

1 Introduction

This Annex gives information about the ground conductivities in various areas of the world, in the form of a World Atlas of Ground Conductivities. This information is intended to be used for field-strength predictions in connection with the ground-wave propagation curves contained in Recommendation ITU-R P.368.

2 Preparation of conductivity maps

In its work on the World Atlas, the ITU-R needs information from every administration. Conductivity maps have been presented in different ways, but in future it would be helpful if they were presented with the same standard set of values of conductivity as indicated in Recommendation ITU-R P.368 and as shown in Table 1.
3 The Atlas

The contents of the Atlas are as follows:

Figs. 1-6: VLF conductivity maps
Figs. 7-43: MF conductivity maps

### TABLE 1

<table>
<thead>
<tr>
<th>Standard values (S/m)</th>
<th>Limiting values of the range (S/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper limit</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>$3 \times 10^{-2}$</td>
<td>$5.5 \times 10^{-2}$</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>$1.7 \times 10^{-2}$</td>
</tr>
<tr>
<td>$3 \times 10^{-3}$</td>
<td>$5.5 \times 10^{-3}$</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>$1.7 \times 10^{-3}$</td>
</tr>
<tr>
<td>$3 \times 10^{-4}$</td>
<td>$5.5 \times 10^{-4}$</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>$1.7 \times 10^{-4}$</td>
</tr>
<tr>
<td>$3 \times 10^{-5}$</td>
<td>$5.5 \times 10^{-5}$</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>$1.7 \times 10^{-5}$</td>
</tr>
</tbody>
</table>

3.1 The conductivity maps for the VLF part of the spectrum (Figs. 1 to 6) give values of effective ground conductivity in mS/m and are subject to the following conditions:

- they are limited in application to frequencies up to 30 kHz,
- they contain no allowance for seasonal variations,
- they have been calculated from physiographical and geological data used to define boundaries of the land areas of given conductivity, together with actual conductivity data derived from measurements,
- they represent effective ground conductivities (the effect of terrain is included in the values),
- as it seems likely that seasonal variations will become more important with increasing frequency (as the penetration depth decreases), maps for higher frequencies may need to be presented in such a way that the annual variations are shown. However, data recorded by the Administration of India indicate that at frequencies as high as 1 MHz seasonal variations in the tropics have a negligible influence on propagation.

3.2 The maps for MF, Figs. 7 to 42 and Table 2, give the effective ground conductivities in mS/m. (The maps are standardized to 1 MHz.) These maps are based on measurements and other relevant information provided by the various countries. They contain no allowance for seasonal variations.

3.3 For those areas for which results of conductivity measurements are not available, provisional information for MF use is shown in Fig. 43. It is expected that this information will be superseded by later editions of the World Atlas to be published by the ITU.

3.4 The conductivities on the MF maps are shown as presented by administrations. For those countries not represented in the Atlas, no information has been made available.
4 Future revision of the Atlas

4.1 Administrations are asked to check and, if necessary, revise the information given in this Atlas.

4.2 Administrations are asked to adjust areas of given conductivity so that each conductivity is one of the standard values given in Table 1.

4.3 It is recognized that because of the use of different methods for measuring ground conductivity, discontinuities will occur at the borders between countries. However, administrations are requested to resolve these problems bilaterally.

MAPS OF GROUND CONDUCTIVITY

VLF maps

Fig. 1 Africa
Fig. 2 Asia
Fig. 3 North America
Fig. 4 South America
Fig. 5 Australia
Fig. 6 Europe

MF maps

Fig. 7 Germany (Federal Republic of) – Western part
Fig. 8 Austria
Fig. 9 Belgium
Fig. 10 Denmark
Fig. 11 Spain
Fig. 12 Finland
Fig. 13 Greece
Fig. 14 Republic of Hungary
Fig. 15 Italy
Fig. 16 Norway
Fig. 17 Netherlands (Kingdom of the)
Fig. 18 Portugal
Fig. 19 Germany (Federal Republic of) – Eastern part
Fig. 20 United Kingdom of Great Britain and Northern Ireland
Fig. 21 Sweden
Fig. 22 Armenia (Republic of), Azerbaijani Republic, Belarus (Republic of), Estonia (Republic of), Georgia, Kazakhstan (Republic of), Latvia (Republic of), Lithuania (Republic of), Moldova (Republic of), Uzbekistan (Republic of), Kyrgyz Republic, Russian Federation, Tajikistan (Republic of), Turkmenistan, Ukraine
NOTE 1 – The denomination of a country or of a territory on these maps, as well as the tracing of any borders, do not imply, on the part of the ITU, any position with respect to the political status of such a country or territory, or official recognition of these borders.
FIGURE 2
Asia
FIGURE 3
North America
FIGURE 4
South America
FIGURE 5
Australia
* In particularly mountainous regions, well below 1 mS/m.
FIGURE 9
Belgium
FIGURE 10
Denmark
FIGURE 12
Finland
FIGURE 13
Greece
FIGURE 14
Hungary (Republic of)
FIGURE 15

Italy
FIGURE 16
Norway
FIGURE 18
Portugal
FIGURE 19

Germany (Federal Republic of) – Eastern part
FIGURE 20
United Kingdom of Great Britain and Northern Ireland
FIGURE 21

Sweden
FIGURE 22
Armenia (Republic of), Azerbaijani Republic, Belarus (Republic of),
Estonia (Republic of), Georgia, Kazakhstan (Republic of),
Latvia (Republic of), Lithuania (Republic of), Moldova (Republic of),
Uzbekistan (Republic of), Kyrgyz Republic, Russian Federation,
Tajikistan (Republic of), Turkmenistan, Ukraine.
FIGURE 23
Bosnia and Herzegovina (Republic of), Croatia (Republic of), The Former Yugoslav Republic of Macedonia, Slovenia (Republic of) and Yugoslavia (Federal Republic of)
FIGURE 24
Bangladesh (People's Republic of)
FIGURE 25
Korea (Republic of)
FIGURE 26
India (Republic of)
FIGURE 27
Iran (Islamic Republic of)
FIGURE 28
Israel (State of)
FIGURE 29
Japan
FIGURE 30
Jordan (Hashemite Kingdom of)
FIGURE 31
Thailand

* Mountainous terrain.
FIGURE 32
Lesotho (Kingdom of), South Africa (Republic of), Swaziland (Kingdom of)
FIGURE 33
Botswana (Republic of)
FIGURE 34
Namibia (Republic of)
FIGURE 35
North America (excluding Canada)
FIGURE 36
Central America
FIGURE 37
Canada
FIGURE 38
South America
FIGURE 39
Australia
FIGURE 40
New Zealand
FIGURE 41
China* (People's Republic of)

* Note 1 – The conductivity map of China is based on measurements of 100 kHz signals and checked by LORAN-C signals. The values are also applicable to the MF band.
FIGURE 42
Nigeria (Federal Republic of)*

### TABLE 2
Measurement results for Afghanistan

<table>
<thead>
<tr>
<th>Place of measurement</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Frequency (kHz)</th>
<th>Ground conductivity (mS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kabul</td>
<td>69° 11’</td>
<td>34° 31’</td>
<td>660 1 280</td>
<td>7.5 9.0</td>
</tr>
<tr>
<td>Jalalabad</td>
<td>70° 27’</td>
<td>34° 26’</td>
<td>660 1 280</td>
<td>3.0</td>
</tr>
<tr>
<td>Gardez</td>
<td>69° 13’</td>
<td>33° 35’</td>
<td>660 1 280</td>
<td>2.0</td>
</tr>
<tr>
<td>Ghazni</td>
<td>68° 25’</td>
<td>33° 33’</td>
<td>660 1 280</td>
<td>2.5</td>
</tr>
<tr>
<td>Kandahar</td>
<td>65° 43’</td>
<td>31° 37’</td>
<td>840</td>
<td>1.0</td>
</tr>
<tr>
<td>Herat</td>
<td>62° 12’</td>
<td>34° 21’</td>
<td>630</td>
<td>1.0</td>
</tr>
</tbody>
</table>
FIGURE 43
Provisional MF conductivity map for land areas